# CARNIVOROUS PLANT NEWSLETTER

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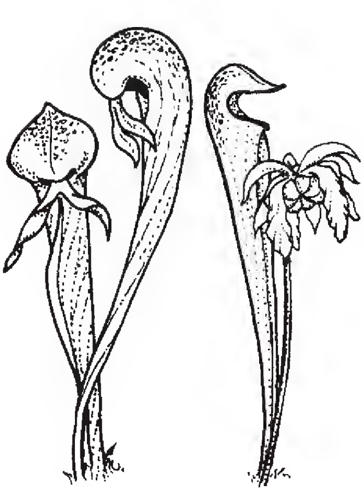


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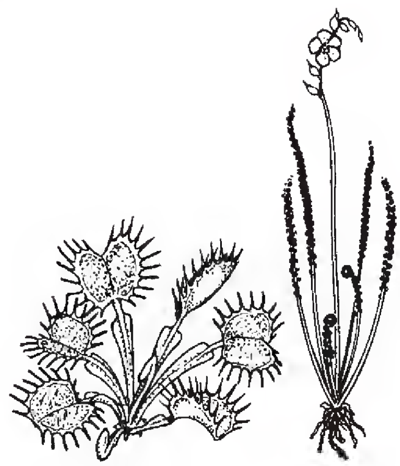

**Front Cover: *Heliamphora* sp. "Angasima Tepui", an undescribed taxon that seems to be related to *H. heterodoxa*. Photo by Butch Tincher. Article on page 137.**

**Back Cover: Orgel Clyde Bramblett with his *Heliamphora*. Photo by Michelle Meeks. Article on page 116.**

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## Contents



## Introducing Greg Bourke
## New ICPS Board Member and Conservation Director

Greg Bourke grew up in the southern suburbs of Sydney with the Royal National Park at its doorstep. It was here he encountered carnivorous plants while bushwalking with his father. Greg's passion for carnivorous plants and photography has since taken him to all corners of the country and into South-East Asia where he has been fortunate to discover and describe several new species. Greg released his first book Australian Carnivorous Plants in 2012 with fellow enthusiast Richard Nunn. Greg is the current president and editor for the Australasian Carnivorous Plant Society, director of Captive Exotics and employee of The Royal Botanic Gardens and Domain Trust in the role of Curator Manager (acting) at The Blue Mountains Botanic Garden, Mount Tomah.

# Orgel Clyde Bramblett (12 August 1930 – 16 February 2013)

Manny Herrera • herrera_manny@yahoo.com

On 16 February 2013, Orgel Clyde Bramblett left us to tend to his great big carnivorous plant garden in the sky … a place where the plants never need watering and the white fly doesn't exist. For many of us, Clyde was a mentor, the first individual who really knew how to grow these fringe plants. We take for granted how far this hobby has come. Not too long ago, it wasn't easy finding good commercial sources for live carnivorous plants and there was only one type of Venus Flytrap. Equally difficult was finding adequate information for the proper cultivation of these overlooked plants. As a child, I recall reading a book on houseplants that dedicated three sentences to carnivorous plants. It instructed me to grow them in "pickle jars" or terrariums, as they could not thrive in less than 100% percent humidity. I will never forget the first time I visited and met Clyde at his nursery, Orgel's Orchids. Up to that point, I had only seen most carnivorous plants in books. I strolled in awe up and down the aisles of Clyde's Lord and Burnham greenhouse filled with *Nepenthes*. They were creeping and crawling all over the place and hanging from the rafters. I left, that day, with my first *Sarracenia*, *Drosera*, *Pinguicula*, and *Nepenthes* plants. Some of which, are still in my collection over twenty years later. Clyde was a pioneer in the importation and breeding of *Nepenthes*. Many of the species and hybrids we grow today, originated with Clyde. He was an ardent explorer of the woods and bogs of the southeast and Gulf Coast, discovering some of the best *Sarracenia* sites known today.

Clyde was an endless source of knowledge and plants. Equal to – if not greater than – his insight were his generosity and kindness. It took only a few visits to Clyde's place before he stopped letting me buy plants and just gave them to me. He was the target of all my interrogations and zeal regarding carnivorous plants. Never did he display annoyance. Though, an annoying 12-year-old I was. He took my many phone calls and acquiesced to my frequent requests for visits, for Clyde would happily talk at length to any who would listen. As with any visitor, he was always eager to walk with me through his greenhouse and grow area, entertaining all inquisitions and silly remarks. He loved to pour over his extensive collection of photographs of carnivorous plants "in the wild", as we would say. Those who knew Clyde will always remember his slideshows, which he'd project onto the wall of his living room. To this day, those are some of the finest shots of *Sarracenia* in locations (many of which are no more) I've ever seen. Clyde's passion for plants, as a whole, and his enjoyment of life were accentuated by his permanent positive attitude. He was the consummate storyteller and jokester.

Aside from his interest in plants, Clyde was a dedicated husband, father, and grandfather. As a pilot and aviator, he was an Air Force veteran of the Korean War, and was awarded the Bronze Star for actions he took during his service. A man of faith, Clyde was actively involved in his local church and was ready to share a message of inspiration and compassion, when it was needed. He left an ineffaceable mark on our hobby and lives. We will never forget him.

# Variation in floral fragrance of tuberous *Drosera*

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Keywords: floral aroma, tuberous *Drosera*.

## Introduction

Floral fragrance is not widely developed in the genus *Drosera*, and little has been written about this feature. Interestingly, most species with fragrant flowers are found in Australia and comprise some pygmy *Drosera* (*Drosera* subgenus *Bryastrum* section *Lamprolepis* Planch.) such as *D. dichrosepala* Turz., D. *enodes* N.G.Marchant & Lowrie, *D. paleacea* subsp. *trichocaulis* (Diels) N.G.Marchant & Lowrie, and D. *roseana* N.G.Marchant & Lowrie (Lowrie 1987) and most of the tuberous sundews (*Drosera* subgenus *Ergaleium*) (Lowrie 1987), such as *D. heterophylla* Lindl. (Bourke & Nunn 2012), *D. praefolia* Tepper (Gibson 1995), *D. prostratoscaposa* Lowrie & Carlquist (Lowrie & Carlquist 1990) and *D. rupicola* (N.G.Marchant) Lowrie (Lowrie 1987). Five species of sundew with sweetly scented flowers have recently been reported from northern South America: *D. amazonica* Rivadavia, A.Fleischm. & Vicent., *D. arenicola* Steyerm., *D. felix* Steyerm. & L.B.Sm., *D. kaieteurensis* Brumm.-Ding., and *D. solaris* A.Fleischm., Wistuba & S.McPherson (Rivadavia *et al.* 2009); all of which are found in *Drosera* subgenus *Drosera* section *Oosperma* Schlauer. This paper presents a summary of my observations of floral fragrance in the tuberous sundew (*Drosera* subgenus *Ergaleium* (DC.) Drude).

Petal fragrance is one of several means that plants use to attract visitors to flowers to facilitate pollination (*e.g.* Miyake & Yafuso 2003). This is particularly important in groups of plants, such as tuberous *Drosera*, for most are self-incompatible and therefore rely on successful cross-pollination in order to set seed (Lin *et al.* 1997).

Over the last 20 years I have opportunistically smelt the flowers of tuberous *Drosera* when encountered in cultivation and in the wild. Some flowers were dissected to identify the source of the volatile compounds. Following Raguso (2004a) the floral scents I detected could be likened to the fragrance of some familiar items: sucrose or nectar = "nectar sweet"; ripe melons or similar smelling fruit = "fruity sweet"; *Dianthus* cultivars = "carnation-like"; or a mix of mold-like aroma combined with the smell of nectar = "musty sweet". To my nose the flowers of some taxa were unscented.

The relative strength of floral odor was also found to vary between taxa, and the threefold classification used here was based on the approximate distance from the flower before the odors were unambiguously detectable (on fine and calm days) and are given as follows: greater than 5 meters = "strong"; between 5 meters and about 0.1 meters = "moderate"; and 0.1 meters or less = "weak".

Flowers of most of the currently described taxa of tuberous *Drosera* were sampled for this project. The exceptions are given below: In the rosetted tuberous *Drosera* (section *Erythrorhiza* (Planch.) Diels): *D. browniana* Lowrie & N.G.Marchant, *D. prostratoscaposa* Lowrie & Carlquist, *D. schmutzii* Lowrie & Conran, and *D. zonaria* Planch.; in the fan-leaved sundews (section *Stolonifera* (Planch.) DeBuhr): *D. monticola* (Lowrie & N.G.Marchant) Lowrie and *D. prostrata* (N.G.Marchant & Lowrie) Lowrie; and in the Rainbow Sundews (section *Ergaleium* (DC.) Drude): *D. gigantea* subsp. *geniculata* N.G.Marchant & Lowrie, *D. neesii* subsp. *borealis* N.G.Marchant, some forms of *D. macrantha* Endl. subsp. *macrantha*, *D. menziesii* R.Br. ex DC. subsp. *menziesii* (orange petal form), *D. menziesii* subsp. *thysanosepala* (Diels) N.G.Marchant, *D. myriantha* Planch., *D. neesii* subsp. *borealis* N.G.Marchant, and *D. prostratoscaposa*.

## Results

Flower fragrance was found to be produced by the petals. The results of this study are summarized below and are discussed in accordance to each of the three sections of the subgenus.

Rosetted tuberous *Drosera* (section *Erythrorhiza* (Planch.) Diels)

The majority of the rosetted tuberous sundews sampled had nectar sweet floral fragrance of moderate strength. The exceptions were the fruity sweet scents of flowers of both subspecies of *D. macrophylla* Lindl.

Figure 1: *Drosera macrantha* subsp. *macrantha* "silky sepal form" showing the distinctive hairs on the inflorescence. This sundew, from the Wongan Hills, has sugary sweet scented flowers and thus differs from all other forms of this subspecies sampled for this project.

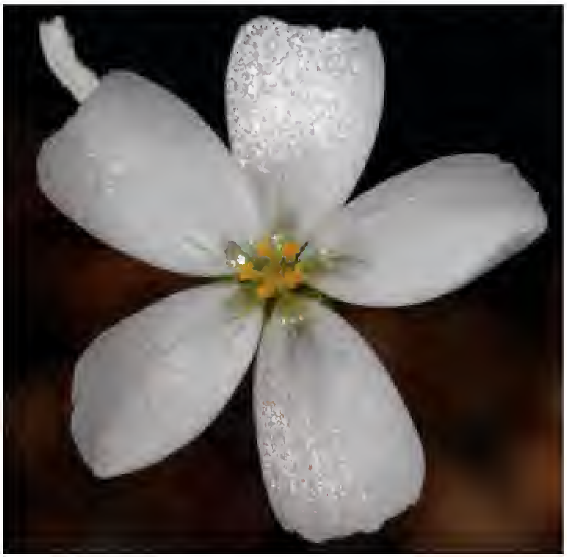

Figure 2: *Drosera radicans* is one of the few tuberous sundew found to have unscented flowers in this study.

Figure 3: *Drosera moorei* flowers have a nectar sweet scent and wonderful bright yellow color.

Figure 4: *Drosera marchantii* subsp. *marchantii* plants flower in abundance after fire and have large and abundant flowers with a strong fruity sweet scent.

| Table 1. Summary of odor type and relative strength of sampled members of *Drosera* subgenus *Ergaleium* section *Ergaleium*. Legend: S = strong; M = moderate; W = weak. |
|---|
| <u>Unscented (to my nose)</u><br>*D. bicolor* Lowrie & Carlquist, *D. bulbigena* Morrison, *D. marchantii* subsp. *prophylla* N.G.Marchant & Lowrie, *D. microphylla* Endl., *D. radicans* N.G.Marchant (Fig. 2) |
| <u>Nectar Sweet</u><br>*D. auriculata* Backh. ex. Planch. (W), *D. graniticola* N.G.Marchant (S), *D. heterophylla* (S), *D. huegelii* Endl. (S), *D. hookeri* R.P.Gibson, B.J.Conn & Conran (W), *D. intricata* Planch. (M), *D. lunata* Buch.-Ham. ex DC. (W), *D. menziesii* subsp. *menziesii* (pink petalled plants) (M), *D. menziesii* subsp. *basifolia* N.G.Marchant & Lowrie (M), *D. modesta* Diels (S), *D. moorei* (Diels) Lowrie (W) (Fig. 3), *D. neesii* Lehm. subsp. *neesii* (M), *D. peltata* Thunb. (W), *D. salina* N.G.Marchant & Lowrie (W), *D. subhirtella* Planch. (M), *D. sulphurea* Lehm. (M), *D. yilgarnensis* R.P.Gibson & B.J.Conn (W), *D. zigzagia* Lowrie (M) |
| <u>Fruity sweet</u><br>D. *gigantea* Lindl. subsp. *gigantea* (M), *D. macrantha* subsp. *macrantha* "silky sepal form" (S), *D. marchantii* DeBuhr subsp. *marchantii* (S) (Fig. 4) |
| <u>Carnation-like</u><br>*D. erythrogyne* N.G.Marchant & Lowrie (M), *D. pallida* Lindl. (M) |
| <u>Musty Sweet</u><br>*D. andersoniana* W.Fitzg. ex Ewart & Jean White (S), *D. macrantha* subsp. *eremaea* N.G.Marchant & Lowrie (M), *D. macrantha* subsp. *macrantha* (most forms) (M), *D. macrantha* subsp. *planchonii* (Hook.f. ex Planch.) N.G.Marchant (M), *D. menziesii* subsp. *penicillaris* (Benth.) N.G.Marchant & Lowrie (S), *D. stricticaulis* (Diels) O.H.Sarg. (M) |

Fan-leaved tuberous *Drosera* (section *Stolonifera* (Planch.) DeBuhr)

All members of the fan-leaved sundews sampled were found also to have nectar sweet blossoms, most of which had moderate strength with the exceptions of *D. fimbriata* DeBuhr and *D. platypoda* Turcz. (both strong) and *D. ramellosa* Lehm. (weak).

Rainbow Sundews (section *Ergaleium* (DC.) Drude)

The Rainbow Sundews sampled revealed a greater diversity of floral scents and relative strengths than other members in other sections of the subgenus (Table 1). The sampling included a number of different morphological forms of *D. macrantha* subsp. *macrantha* including a form from near the Wongan Hills that has long silky hairs on the inflorescence (henceforth the "silky-sepal form": Fig. 1) that had a different floral scent to all other plants of *D. macrantha* sampled.

## Discussion

In contrast to other subgenera in the genus *Drosera* the majority of tuberous *Drosera* taxa have detectable floral scents; all of which are produced by the petals in the taxa sampled, and only when the flowers were open. In addition, tuberous *Drosera* taxa display a variety of floral scents which may correlate to different classes of scent compounds. Some groups of taxa with shared morphological characters also share the same type of floral aroma, such as: *D. erythrogyne* and *D. pallida*; *D. andersoniana, D. stricticaulis*, and most forms of *D. macrantha* subsp. *macrantha*; and *D. moorei* and *D. zigzagia*. However, there are also taxonomic groups with members with variation in floral scents: such as *D. menziesii* subspecies and for at least one entity in the *Drosera macrantha* complex.

Floral fragrance type does not appear to correlate well with petal color or flower size. It may be that differences in floral attributes have developed between some tuberous *Drosera* where they grow sympatrically to attract insects that act as pollinators with high fidelity to each taxon of sundew. This is important because many taxa of tuberous *Drosera* grow and flower together, and therefore floral aroma may be one way of ensuring compatible pollen is brought between flowers of the same taxon in order to promoting cross-pollination (Raguso 2004b).

## Recommendations for Further Work

The human nose is an imprecise tool for quantifying aromas. It is possible to methodically collect floral aromatic compounds by such techniques as headspace sorption, and then identify each aromatic compound and their abundance by gas chromatography and mass spectrometry (*e.g.* Huber *et al.* 2005). Some or all of these techniques could be used to test the flowers of all tuberous *Drosera*. This would allow the results of floral aromatic chemistry to be mapped onto a phylogeny of the subgenus to test the stability of floral scents (and other floral features) in the evolution of the genus; for example, do all yellow-petalled tuberous *Drosera* share the same floral aromatic chemistry, and do they form a natural group derived from one common ancestor?

These techniques could be expanded to include the entire genus, and examine, for example, whether or not the same aromatic floral compounds occur in different subgenera? It could also be that volatile aromatic compounds occur widely in the genus, only some of which are detectable to the human nose.

## Conclusions

This pilot study has identified floral fragrance in most tuberous *Drosera* sampled, and found that the nature and strength of the floral odor varies between taxa, but that the broad type of odor is often shared between morphologically similar taxa. I recommend that volatile floral aromatic compounds are examined in a more rigorous way, with analytical equipment to examine the extent and nature of these compounds in the genus. And finally, I found the floral aromas pleasant to irresistible (particularly the carnation-like scent of *D. erythrogyne* and *D. pallida*). Therefore when next you get the chance, I recommended that you take time and smell the *Drosera* flowers.

Acknowledgements: I thank Yves-André Utz for discussions that helped start and maintain this study and I thank Greg Bourke, Kirk “Füzzy” Hirsch, Phill Mann, and Mark Stuart for helpful discussions and the provision of samples that were used in this study.

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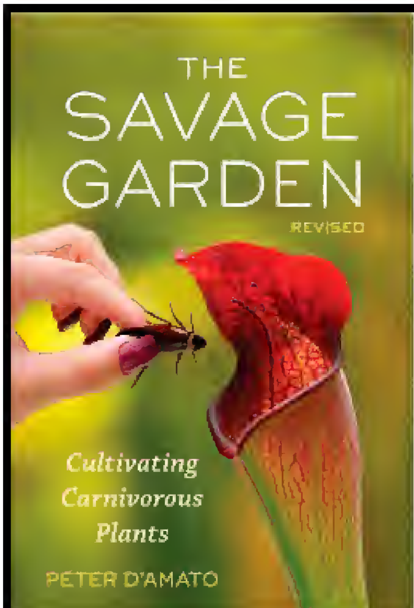

# A new way to identify living species of *Nepenthes* (Nepenthaceae): More data needed!

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Keywords: identification; *Nepenthes*, Nepenthaceae, pitcher height, pitcher volume.

## Summary

We present a possibly simple and effective way to identify living specimens of the various species of *Nepenthes*. The volume and height of the pitchers are closely correlated variables of which the mathematical relationship between them can be expressed in a simple formula. These formulas, preferably of the upper pitchers when available, are slightly different for most species investigated, especially for the largest pitchers on specimens. This method is easily applicable in Botanical Gardens, which generally have a small, highly similar set of species. However, the results are based on few data (few specimens per species, only from two botanical gardens). Thus, please help, by providing more data, especially of hybrids, to further test the method.

## Like to Help?

a. Note of a specimen its identification (species name), name and number of collector, origin (of course when known). Please, indicate how reliable you consider the identification to be.
b. empty all **upper** pitchers per specimen (avoid lower pitchers, unless upper pitchers are lacking). Note how many pitchers you measure and, if only lower pitchers are available, indicate this.
c. fill the emptied pitchers with water (keep mouth horizontal, Fig. 1c) and poor the content into a measuring cylinder and note for each pitcher the volume in preferably cubic centimeters.
d. measure the height of the upper pitchers (Fig. 1a & b) and note the heights per pitcher in centimeters.
e. send the data to the Dr. Paul Kessler, Hortus botanicus in Leiden (address under authors), do not forget your own name and address.
f. Many thanks!

## Introduction

One of the attractive plant genera in Asia is *Nepenthes* L., a genus of *c.* 87 species (Jebb & Cheek 1997). The genus is famous for its leaf tips, which are transformed into pitchers. The pitchers apply “slippery wax crystals on the inner pitcher wall and ‘insect aquaplaning’ on the wet upper rim (peristome)” (citation from Bauer *et al.* 2011) to trap and digest mainly arthropods. The arthropods are lured to the pitchers by extrafloral nectaries (Merbach *et al.* 1999). The additional nitrogen and

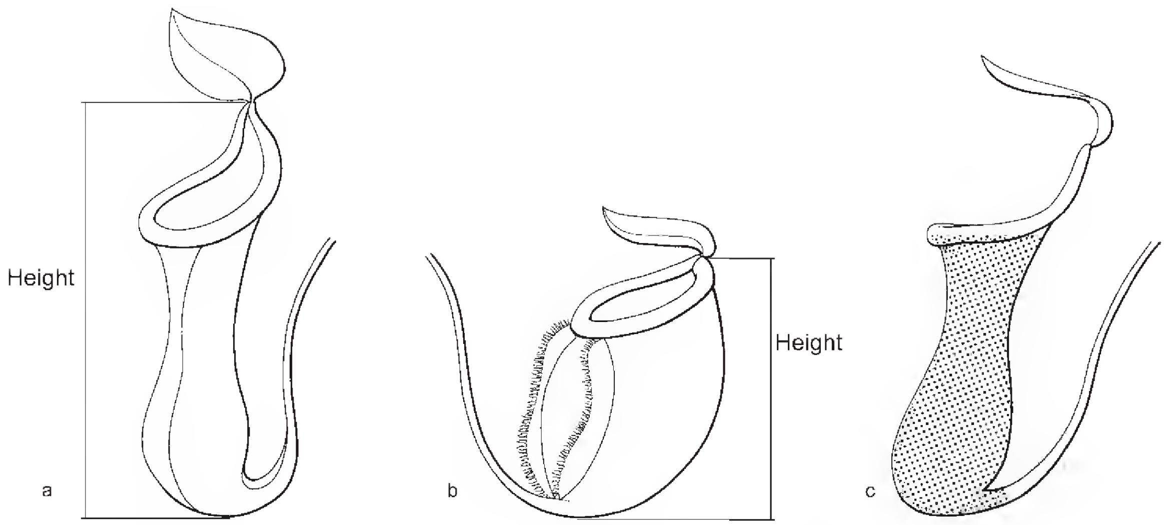



Figure 1: Showing how to measure height of the pitcher (a & b) and the content (c). a. upper pitcher (petiole attachment and lid at same side of pitcher); b. lower pitcher (petiole attachment and lid at opposite sides of pitcher).

phosphate thus obtained allows the pitcher plants to grow in nutrient poor surroundings. However, not all pitcher plants trap arthropods for extra nutrients, *N. ampullaria* Jack (Fig. 2a) is reported to grow in dense woods and to trap leaf litter (Moran *et al.* 2003), while *N. rajah* Hook.f., the species with the largest pitchers, is occasionally reported to catch small mammals (Phillipps & Lamb 1996: 131), but this is probably accidental as the species is reported to live mutualistically with small mammals that defecate in the pitchers (Greenwood *et al.* 2011; Wells *et al.* 2011).

Until now, species were always identified morphologically (Clark 1997; Jebb & Cheek 1997; Cheek & Jebb 2001). This is often difficult because differences might be small or characters may be difficult to find. A second way of identification, presently being developed, is DNA-barcoding whereby short sequences of two or three regions in the chloroplast DNA should be typical for a species. This is still a rather expensive and time consuming method, which still has to be performed in a laboratory.

Three-dimensional shapes that are reiterated on an object are usually constant in proportions like the pitchers, young and older, on the same individual. The iterations may show variation in sizes, but the overall shape remains constant. Consequently, the mathematical relations between the various components that make up for the three-dimensional shape can be expressed in relatively simple formulas.

Here we like to investigate whether the pitchers of *Nepenthes* possess two or more variables that show a constant, mathematical relationship per species, but differ slightly to strongly among species. If these are found, then pitcher variables can be used to identify the species even outside a laboratory.

## Material and Methods

The volume of the (preferably) upper pitchers and several simple measurements like height and width of the pitcher, *etc.* were measured. It quickly became evident that especially the height of the pitchers in combination with the volume provided sufficiently different results between the species to ignore the other variables.

The volume of the pitchers was measured by first emptying and cleaning the pitcher from all fluids and debris, then filling it with water till the rim of the mouth, which generally meant that the


Figure 2a: *Nepenthes ampullaria* Jack showing detritus in pitchers (photo: Rogier van Vugt, Malaysia, Gunung Jerai); b: *N. albomarginata* T.Lobb ex Lindl., green form (photo: Rogier van Vugt, Hortus botanicus University of Leiden, originally from Malaysia, Sarawak, Bako National Park); c: *N. albomarginata* T.Lobb ex Lindl., purple form from Malaysia (photo: Rogier van Vugt, Malaysia, Bukit Bendera).

mouth of the pitcher needed to be held horizontally (normally the mouth is somewhat diagonal; Fig. 1a & b). The content was then collected in a cylinder with a scale. Depending on the size of the pitchers, cylinders of 10, 50, 100, and 250 ml were used. The height of the pitchers was measured with a ruler from the base of the cup (where the tendril ends and the actual pitcher begins) to where the lid is attached to the pitcher (highest point of the diagonal mouth; Fig. 1c). The ruler must be held parallel to the pitcher in such a way that the ruler is in line with the two measuring points.

The species and specimens studied (Table 1) are all measured from living collections in the Hortus botanicus Leiden, Leiden University, Leiden, The Netherlands and the Royal Botanic Gardens Melbourne, Melbourne, Australia. Care was taken to measure all pitchers per plant, and also, when possible, more than one specimen per species, whereby the geographical origin of the sample was noted.

The mathematical relationship between volume and height was analyzed per species with Microsoft Office Excel 2007, whereby various types of functions were examined and the highest $R^2$-values were used to select the best fitting function.

## Results

The measurements, volumes and heights, are shown in Fig. 3a. The best fitting functions are plotted through the data. The formulas of the functions and their $R^2$-values are shown in Table 2. For most species it appeared that simple exponential functions described the mathematical relation between volume and height best, the two exceptions are *N. albomarginata* T.Lobb ex Lindl. (Borneo) with a linear function and *N. mirabilis* (Lour.) Druce var. *mirabilis* with a polynomial function.

## Discussion

The measurements per species were obtained from a number of genetically different individuals and from a number of cuttings of these individuals (Table 1); the only two exceptions were *N. mirabilis* var. *globosa* M.Catal. and *N. alata* Blanco of which only one plant was available in the Hortus botanicus Leiden and the Royal Botanic Gardens Melbourne, respectively. Measuring various speci-

| Table 1. The measurements of species and specimens. | | | |
|---|---|---|---|
| Species [origin] (no. genetically unique plants) | Specimen number* | No. pitchers measured | Pitcher type |
| *N. alata* Blanco [unknown] (1) | 020224 (RBGM) | 16 | upper |
| *N. albomarginata* T.Lobb ex Lindl. [Borneo, Sarawak] (1) | 20050998 (HB) | 6 | upper |
| *N. albomarginata* T.Lobb ex Lindl. [Malay Peninsula] (6) | 960378 (cutting) (HB) | 6 | upper |
| | 960378 (cutting) (HB) | 4 | upper |
| | 950470 (HB) | 2 | upper |
| | 960382 (HB) | 3 | upper |
| | 950467 (HB) | 1 | upper |
| | 950466 (HB) | 1 | upper |
| | 960375 (HB) | 4 | upper |
| *N. ampullaria* Jack [cultivated] (2) | 20051574 (cutting) (HB) | 6 | lower |
| | 20051574 (cutting) (HB) | 7 | lower |
| | 20040012 (HB) | 3 | lower |
| *N. maxima* Reinw. ex Nees [cultivated] (1) | HBL31076 (cutting) (HB) | 9 | upper |
| | HBL31076 (cutting) (HB) | 3 | upper |
| *N. merrilliana* Macfarl. [cultivated] (2) | 930070 (cutting) (HB) | 6 | upper |
| | 930070 (cutting) (HB) | 6 | upper |
| | 930070 (cutting) (HB) | 5 | upper |
| | 20060048 (HB) | 1 | upper |
| *N. mirabilis* (Lour.) Druce var. *globosa* M.Catal. [cultivated] (1) | 20090052 (HB) | 7 | lower |
| *N. mirabilis* (Lour.) Druce var. *mirabilis* [various] (3) | 930053 (HB) [Sulawesi] | 6 | upper |
| | 960329 (cutting) (HB) [Malay Peninsula] | 9 | upper |
| | 960329 (cutting) (HB) [Malay Peninsula] | 3 | upper |
| | 960329 (cutting) (HB) [Malay Peninsula] | 3 | upper |
| | 20050997 (HB) [Australia] | 1 | upper |
| *N. smilesii* Hemsl. [cultivated] (1) | 792749-19755 (cutting) (HB) | 6 | upper |
| | 792749-19755 (cutting) (HB) | 3 | upper |
| | 792749-19755 (cutting) (HB) | 5 | upper |
| *N. ventricosa* Blanco [cultivated] (3) | 910137 (HB) | 15 | upper |
| | 930733 (HB) | 3 | upper |
| | 020245 (RBGM) | 6 | upper |

* HB = Hortus botanicus Leiden; RBGM = Royal Botanical Gardens Melbourne.

| Table 2. The formulas of the best fitting functions and their $R^2$-values. | | | |
|---|---|---|---|
| Species (number of genetically unique plants) | Formula of best fitting functions | $R^2$-values | Type of function |
| *N. alata* Blanco (1) | $1.2359e^{0.2882x}$ | 0.9578 | exponential |
| *N. albomarginata* T.Lobb ex Lindl. (Borneo) (1) | $2.3005x - 13.089$ | 0.9392 | linear |
| *N. albomarginata* T.Lobb ex Lindl. (Malay Peninsula) (6) | $1.2602e^{0.306x}$ | 0.9583 | exponential |
| *N. ampullaria* Jack (2) | $2.2767e^{0.3982x}$ | 0.7242 | exponential |
| *N. maxima* Reinw. ex Nees (1) | $8.4462e^{0.1046x}$ | 0.9379 | exponential |
| *N. merrilliana* Macfarl. (2) | $5.3004e^{0.1773x}$ | 0.9019 | exponential |
| *N. mirabilis* (Lour.) Druce var. *globosa* M. Catal (1) | $0.5727e^{0.5277x}$ | 0.958 | exponential |
| *N. mirabilis* (Lour.) Druce var. *mirabilis* (3) | $0.1082x^2 + 1.7353x - 8.1235$ | 0.8899 | polynomial |
| *N. smilesii* Hemsl. (1) | $0.5987e^{0.3953x}$ | 0.9378 | exponential |
| *N. ventricosa* Blanco (3) | $1.1037e^{0.3941x}$ | 0.922 | exponential |

mens was done to check if the functions were indeed species-specific or individual-specific. The sample is still small and needs further elaboration with more species and more individuals per species.

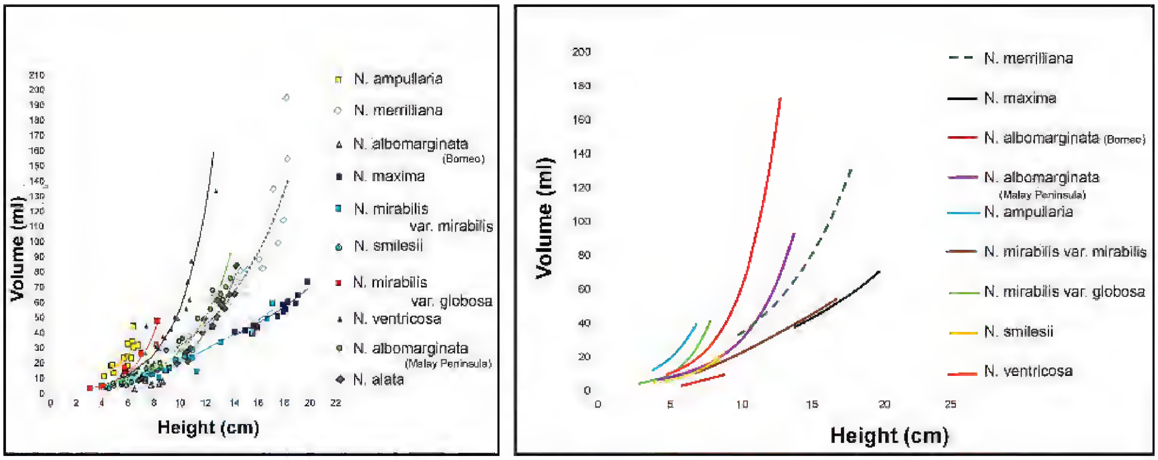
A second problem is that only specimens from two botanical gardens (mainly Leiden) were used. Usually, the conditions per garden are controlled in the same way for all specimens present, which may decrease the variability among genetically different specimens. Thus, additional measurements from other gardens or private collections are in high demand.

The extra data may also help to solve a third problem. The genetically different individuals often still came from the same area of origin (*e.g.*, 6 specimens of *N. albomarginata* T.Lobb ex Lindl. from the Malay Peninsula) and, therefore, the full variability per species has not yet been explored completely.

Botanical gardens prefer to have true species in their collections and no hybrids. However, the trade in pitcher plants is generally a trade in hybrids. Adding measurements on hybrids will be a great addition and allows us to see whether the measurements will be intermediate or not with those of the parent species.

When we consider the results so far, then we found little or no variation between the individuals of a species or for the different pitchers on the same plant specimen, thus volume and height of pitchers are specific for the species. Small and large pitchers within the same species show the same shape ratios. This is demonstrated by the high $R^2$ values (Table 2), which are generally above 0.9 (with *N. ampullaria* – Fig. 2a – and *N. mirabilis* var. *mirabilis* as exceptions). Mind you, our $R^2$ values are probably inflated as we had to treat all measurements, often of the same plant, as independent in order to find a mathematical function. The artificially higher $R^2$ values are not a problem as they were all only used to select the best fitting functions.

*Nepenthes* plants show two kinds of pitchers, lower (ground) and upper (aerial) pitchers (Moran 1996). Lower pitchers are attached to the leaf with the site opposite to the lid (Fig. 1b, 2a, somewhat difficult to see) and are generally present in the lower part of the plant. They are usually larger, especially basally, than the upper pitchers. Lower pitchers can even become very large when resting




a b

Figure 3a: Species-specific relationships between volume and height for the pitchers of some species of *Nepenthes*. These relationships are the species-specific functions that can be used for identification of the species; b: The representations of the mathematical functions that best fit the relationship between volume and height and which can be used for the identification of the species.

on the soil. Upper pitchers are more slender and attached to the leaf with the side that carries the lid (Fig. 1a, 2b, c); these are always in the upper part of the plant. A species like *N. ampullaria* generally only has basal pitchers, very exceptionally also upper ones (Clarke & Moran 1994; Fig. 2a). The differences between the types of pitcher probably explain the difference between the two varieties of *N. mirabilis*. Of var. *globosa* only one plant was present in the Hortus botanicus Leiden with only lower pitchers, while the other variety showed plants with upper pitchers. On the other hand, the difference may also be due to evolutionary differentiation. The method we developed was mainly applied to upper pitchers (Table 1), with *N. ampullaria* and *N. mirabilis* var. *globosa* as exceptions. Of the latter two, only normal lower pitchers were used and not the exceptionally large ones. Though we like to concentrate on the upper pitchers, as these are usually generally available, a comparison with the lower pitchers will prove interesting. These data are welcome too, but take care to note which measurements were taken from lower pitchers.

Only the data of *N. albomarginata* T.Lobb ex Lindl. showed different results for Borneo (Fig. 1b) and the Malay Peninsula (Fig. 1c). The various plants from these regions also looked morphologically quite different, and, therefore, the localities were separated in the analysis. This means that the identification method may be robust enough to separate geographical variants of widespread species.

By only plotting the best fitting functions of each species (Fig. 3b), the graphs become much clearer and more useful as a determination chart. Several of the functions cross each other. This is mainly the case for the smaller sized pitchers. Thus, it is best practice to always measure the largest pitchers on a specimen, then identification is easiest, *e.g.* check the graphs of *N. albomarginata* from the Malay Peninsula, *N. maxima* Reinw. ex Nees, *N. merrilliana* Macfarl., *N. mirabilis* var. *globosa*, and *N. ventricosa* Blanco. Where species-specific functions more or less completely cross, additional determination keys are needed to identify the species correctly. This means that the original determination keys are still partly needed. This is especially the case with the species with smaller pitchers (Fig. 3a).

Two taxa show a different optimal function than exponential, linear for *N. albomarginata* from Borneo and polynomial for *N. mirabilis* var. *mirabilis*. This may seem very anomalous, but the $R^2$ values for an exponential function were only slightly lower. It is still uncertain whether the pitcher

length/contents ratio of these species really follows other mathematical functions or that it is due to a limited sample size.

The graphs in Fig. 3b can be used for identification. Measure the height and volume of the largest pitchers of your plants and plot them in the diagram. The nearest line should indicate the correct species.

## Conclusion

The method presented here has great potential to help identifying living species of *Nepenthes*. Still, many more species need to be measured and added to the determination graph, whereby geographical variation has to be checked. Also, the influence of hothouse conditions has to be compared with the measurements of wild specimens.

Acknowledgements: We thank the director of the Hortus botanicus in Leiden for granting us permission to use the plants in the greenhouses; Art Vogel is thanked for showing us around and Gerda van Uffelen for providing information concerning the origin of the studied plants. Hayden Birch is acknowledged for guiding us in the Royal Botanic Gardens in Melbourne. Two anonymous reviewers are thanked for their critical remarks, which improved the content of this paper.

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# Mice feeding on *Sarracenia* secretion

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This story started a couple of years back when I arrived at my New Zealand greenhouse and found a pair of native nectar feeding birds we call wax eyes (*Zosterops lateralis*) flying along the inside of the greenhouse and hanging around a group of autumn *Sarracenia leucophylla* pitchers. I managed to take a couple of very average photos of the wax eyes feeding from the mouths of the *S. leucophylla*.

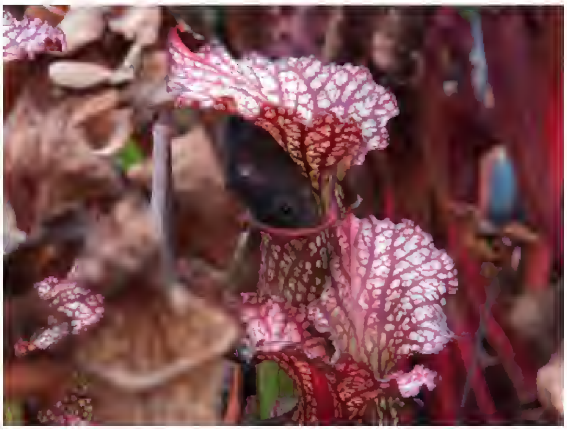
One season later, I was "working" in the greenhouse on my sun lounger when a mouse appeared about 2 meters away and ran along the frame of a bog constructed on the floor next to where I was sitting containing *Sarracenia*. The mouse then climbed up into the bog and I could track its progress by the movement of foliage as it made its way through the various pots. The mouse then reappeared, climbing straight up the side of a *S. leucophylla* trumpet and proceeded to lick the areas of the pitcher rim, mouth, inner hood, and down into the trumpet. The mouse took its time making sure all the nectar was taken. It then proceeded back down to the pot and up an adjoining pitcher continuing the same feeding pattern. There was frustration involved in this as I knew if I moved it would scare the mouse and any photo opportunity would be gone. In any case I didn't have my camera within arm's reach.

I have witnessed this behaviour on various occasions since that first encounter a year ago, but was never able to have a camera handy at just the right time. Like all wild mice these are a skittery bunch and run for it when they detect movement.

By chance on Saturday 25th May 2013, a well-known CP grower, Heather Frederick, was visiting my *Sarracenia* collection for the first time. We were only a few minutes into the visit when Heather called out and said she'd spotted either a rat or mouse moving through one of the ground bogs. I told Heather there was no problem as rodents commonly frequented the ground bogs to feed from the mouths of the *Sarracenia*. I advised Heather they were not easy to approach and not to bother trying to take photos as they would run off. In the meantime, Heather already had her camera out and was taking photos and videos of the event! I then retreated back to my camera bag and when I returned, Heather was still taking photos of the feeding rodent. Presumably having had enough the mouse eventually disappeared.

I'm not sure if this behaviour of mice feeding from *Sarracenia* as been recorded or photographed before. Thankfully my photos came out OK. It was a highlight of the visit for both myself and Heather and we are keen to hear from other CP enthusiast/researchers who may have experience or knowledge of rodents feeding on *Sarracenia* secretions.

The rodent in these photos is *Mus musculus,* commonly known as either the house mouse or field mouse. It is the sole species of mouse in New Zealand having been introduced by Europeans *circa* 1830. All rodents in New Zealand are introduced.



# Preliminary studies reveal richness of carnivorous plants in an underexplored area of northeastern Brazil

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Brazil is home to several carnivorous plant genera, including *Drosera*, *Genlisea*, *Utricularia*, *Heliamphora*, *Philcoxia*, *Catopsis*, and *Brocchinia*. It is only second to Australia (*c.* 188 species) (Bourke & Nunn 2012; Darnowski *et al.* 2006; Schlauer 2013) in total number of carnivorous plant species, with approximately 125 (Forzza *et al.* 2010; Schlauer 2013).

The majority of carnivorous plant species in Brazil are found in campo rupestre vegetation, mostly along the Cadeia do Espinhaço highlands of Minas Gerais and Bahia states, as well as in savanna areas of central Brazil. Another habitat that is rich in carnivorous plant species is found along coastal areas and is known as restingas (Rivadavia 2002), which occur all along the *c.* 8500 km of coastal Brazil.

Since September 2010, I have been researching Droseraceae and Lentibulariaceae in the state of Paraíba, northeastern Brazil. More specifically, my studies involve ecology and taxonomy of carnivorous plants found along the coastal regions of Paraíba (Fig. 1).

In Paraíba, carnivorous plants occur mainly in "tabuleiro" habitats (Fig. 2), which consist of savanna vegetation (similar to the "cerrado" common to central Brazil), growing over leached sandy soils with numerous natural springs. Tabuleiros are found along the coast of northeastern Brazil and have distinct wet and dry seasons, with temperatures around 15-29°C in the wet season (March to September) and 25-45°C in the dry season (October to February).

Over the past 3 years, I have observed 19 species of carnivorous plants in different regions of eastern Paraíba (Fig. 3 and 4): *Utricularia amethystina* Salzm. ex A.St.-Hil. & Girard, *U. foliosa* L., *U. gibba* L., *U. guyanensis* A.D.C., *U. juncea* Vahl, *U. nana* A.St.-Hil. & Girard, *U. nigrescens* Sylvén, *Utricularia olivacea* C.Wright ex Griseb., *U. pusilla* Vahl, *U. simulans* Pilg., *U. subulata* L., *U. tenuissima* Tutin, *U. trichophylla* Spruce ex Oliv., *U. tricolor* A.St.-Hil., *U. triloba* Benj., *Genlisea filiformis* A.St.-Hil., *G. repens* Benj., *Drosera communis* A.St.-Hil., *D. sessilifolia* A.St.-Hil.

Many of the above species were found growing sympatrically at the numerous sites I have studied. I will give brief descriptions below for each of these species, with a few details on morphology

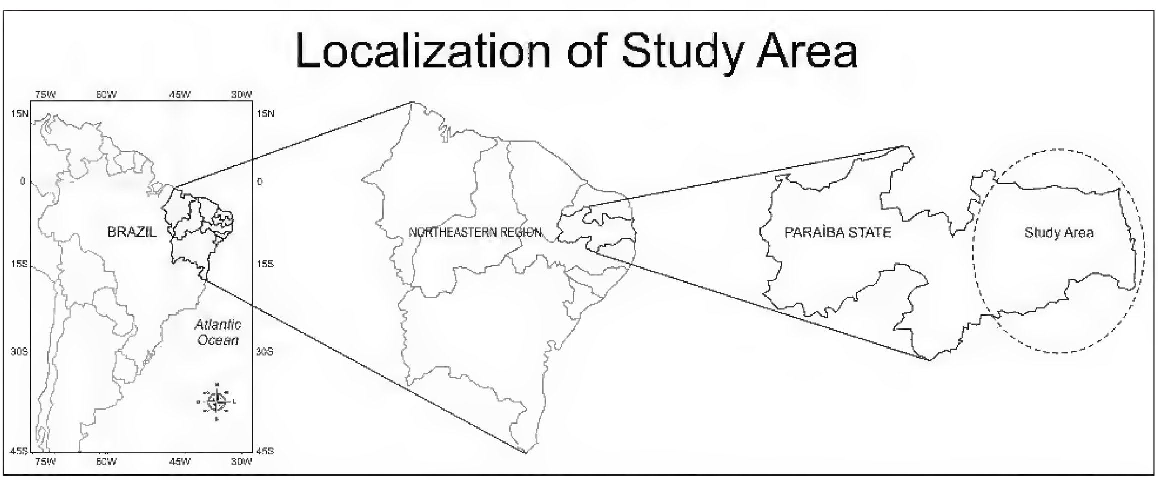


Figure 1: Brazil, northeastern Brazil, and Paraíba State.

Figure 2: Area of tabuleiro habitat.

and the habitats where I observed each in Paraíba. Collections of majority species mentioned above were deposited at JPB Herbarium (Herbário Lauro Pires Xavier) of the Universidade Federal da Paraíba in João Pessoa and are part of my master degree program.

*Utricularia amethystina* (Fig. 4C) is distributed throughout tropical and subtropical America. In Brazil it is widespread in all but the southernmost states, and is relatively rare in the north and northeast (Taylor 1989). In Paraíba this species occurs abundantly in areas distant about 20 km from the coast, between 150 m and 180 m elevation, where it inhabits moist sandy soils, usually near watercourses, forming large populations. This is a highly-variable taxon with flowers varying from purple-blue to white to yellow (Taylor 1989), and will very likely be divided into multiple species in the following years. The local Paraíba form has flowers that are 0.5-1.5 cm long, blue-purple with yellow and white at the base of the lower lip, borne on long stalks measuring 4-16 cm in height, and it grows both as an annual and as a perennial. Its leaves are rounded, often occurring in small rosettes and commonly shaded by grasses.

*Utricularia foliosa* (Fig. 5) is another widespread species known from Africa, North and South America, occurring throughout most of Brazil (except in the southernmost states) (Taylor 1989). In Paraíba I have only personally observed this large aquatic perennial species growing abundantly in a lake about 40 km from the coast at 200 m elevation. The flowers are bright yellow, borne on scapes 10-30 cm in height, the stolons reaching 2 m in length.

*Utricularia gibba* (Fig 3D) is one of the most common *Utricularia* species in Paraíba and is abundant all over Brazil – as well as being one of the most widespread carnivorous plant species in the world, with pantropical distribution (Taylor 1989). I have so far found this perennial aquatic at 6 locations, in streams and lakes ranging 10-100 km from the coast at elevations ranging from 20-300

Figure 3: A) *Utricularia nana*; B) *U. tenuissima*; C) *Drosera sessilifolia*; D) *U. gibba*.

m, usually forming extensive populations. *Utricularia gibba* has thread-like leaves and I observed yellow flowers measuring 0.5-2 cm in diameter on inflorescences measuring 4-7 cm tall. It grows in full sun as a semi-aquatic on wet soil bordering bodies of water.

*Utricularia guyanensis* is a widespread but relatively rare terrestrial annual species known to occur in Central and South America, including the northern half of Brazil. It was placed in its own monotypic section by Taylor, sect. *Stylotheca*, mostly because of its unique elongated style and stamens (Taylor 1989). I encountered *U. guyanensis* in an area of environmental preservation near the coast at 20 m elevation, growing in sandy soils that dry out completely in the dry season. The inflorescences were deep red, measuring 7-15 cm tall, and the flowers a golden yellow color, 1-2 cm long.

*Utricularia juncea* is common across eastern North America, Central America, and northern South America, occurring in northern and northeastern Brazil (Taylor 1989), and apparently grows both as an annual and as a perennial. In Paraiba, I found *U. juncea* growing in areas about 20 km from the coast at 150 m elevation, occurring in wet sandy soil. The yellow flowers measured around 1-2 cm long on scapes 7-18 cm high.

*Utricularia nana* (Fig 3A) is a small perennial species occurring in Guyana, Suriname, Venezuela, and throughout all regions of Brazil (Taylor 1989). It inhabits wetlands in Paraíba, *c*. 20 km from the coast and 150 m elevation and I observed yellow flowers measuring 0.5-1 cm long on scapes 1-3 cm high. Taylor placed this species in its own monotypic section, sect. *Benjaminiana* (Taylor 1989). It grows under full sun in wet sandy soil.

*Utricularia nigrescens* (Fig. 6A) is an annual species very similar to *U. pusilla* (but larger) and endemic to Brazil, where it occurs mainly in the central region (Taylor 1989). I discovered the first population occurring in northeastern Brazil (Forzza 2010), growing at 180 m elevation in sandy soil


Figure 4: A) *Utricularia triloba* Benj.; B) *Drosera communis* A.St.-Hil.; C) *U. amethystina* Salzm. ex A.St.-Hil. & Girard; D) *U. subulata* L.

of a flooded area near a spring *c*. 25 km from the coast of Paraíba, with yellow flowers measuring 1-1.5 cm long and scapes 2-4 cm high.

*Utricularia olivacea* is an aquatic species and also the smallest among the *Utricularia* taxa found in Paraíba. This was the first record of *U. olivacea* in northeastern Brazil (Forzza 2010). The flowers were cream-colored and translucent, measuring only about 0.5 cm in diameter, borne on scapes around 1 cm high. I only found a few specimens inhabiting wetlands about 20 km from the coast, growing in the semi-shade of grasses in a thin film of water over wet soils. When I returned to this location in the dry season, the habitat was completely dry, thus *U. olivacea* appears to grow as an annual at this site.

*Utricularia pusilla* is widespread in Central and South America, occurring in Brazil throughout most of the country, except the southernmost states (Taylor 1989). This annual was also not previously recorded from the state of Paraíba until I collected it in 2012, between 150-180 m elevation, *c*. 20 km from the coast. I found it growing in flooded areas near streams, in wet sandy soils exposed to full sun. The yellow flowers measured around 1 cm long on scapes around 2-4 cm high.

*Utricularia simulans* is found in tropical Africa as well as in the Americas, from Florida to Paraguay and southern Brazil, where it is one of the most abundant and widespread *Utricularia* species (Taylor 1989). In Paraíba it occurs in areas around 50-180 m elevation, between 5-20 km from the coast, where it inhabits humid sandy soils under full sun and grows as an annual. The flowers I observed were a golden yellow in color, measuring around 0.5-1 cm long on scapes 2-6 cm high.

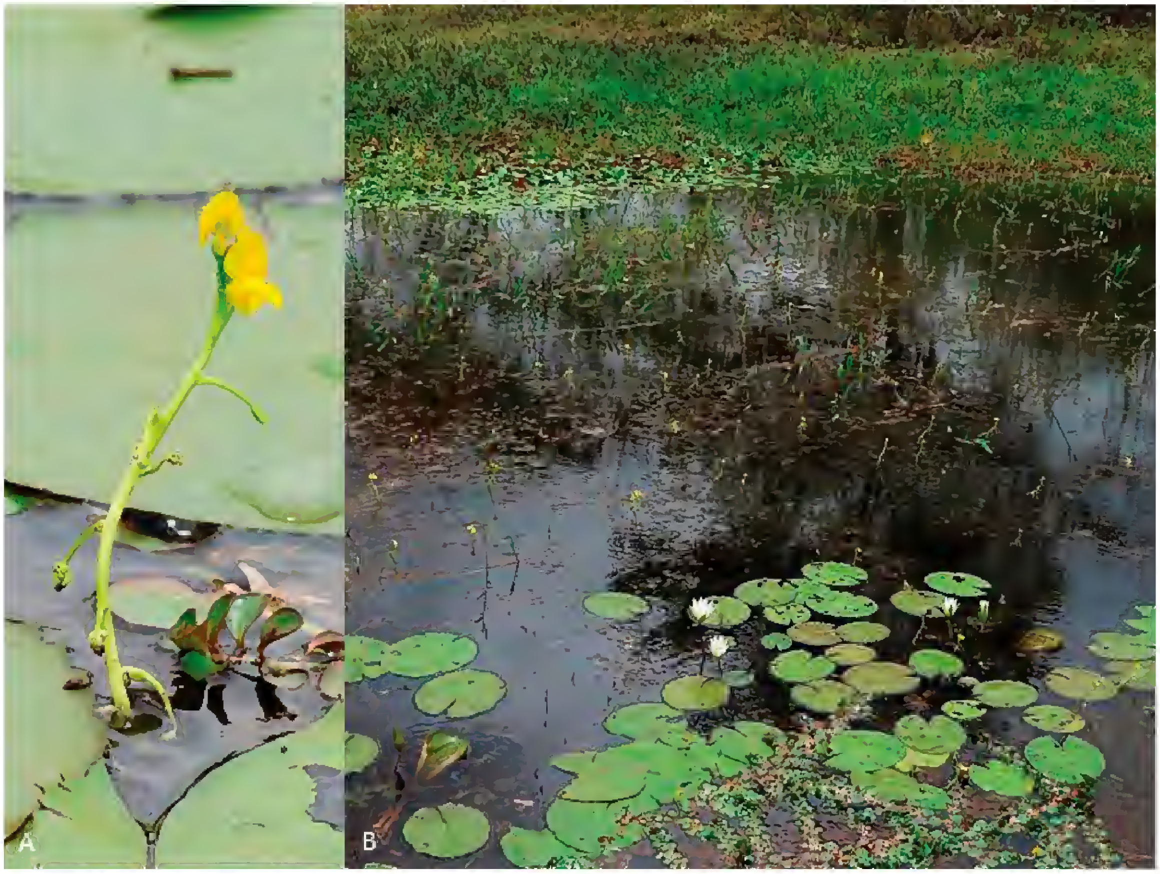


Figure 5: A) *Utricularia foliosa* L.; B) Lake habitat of *U. foliosa*.

*Utricularia subulata* (Fig 4D), not surprisingly, is the most abundant of all *Utricularia* along the coast of Paraíba, occurring in sandy soils and wetlands under full sunlight. It is a pantropical species, the most widespread of all *Utricularia* worldwide and is distributed throughout Brazil (Taylor 1989), where it grows both as an annual and as a perennial. I observed yellow flowers measuring about 1 cm long on scapes around 2-10 cm high.

*Utricularia tenuissima* (Fig. 3B) is a rare species, although widespread in South America, known from Brazil, Colombia, Venezuela, Suriname, Trinidad, and Guyana (Taylor 1989). In Paraíba I found it *c*. 20 km from the coast at 150 m elevation, where it likely grows as an annual. This was the first record of *U. tenuissima* in northeastern Brazil (Forzza 2010). The few tiny flowers encountered were lilac, the base of the lower lip colored white and yellow, measuring about 0.2-0.5 cm long on scapes only 0.5-1 cm high (Taylor 1989). These were growing in wetlands surrounding natural springs, semi-shaded by grasses in wet soils.

*Utricularia trichophylla* is another new discovery for the state of Paraíba, which I encountered between 150-180 m elevation, *c*. 20 km from the coast. It is known to occur in Guyana, Venezuela, and throughout most of Brazil, except in the southernmost states (Taylor 1989). No flowers were observed, only the filiform green leaves submerged along shady margins of a stream. Although described as a perennial species by Taylor (1989), I returned to this same site a few months later and it was completely dry, suggesting *U. trichophylla* may grow as an annual too.

*Utricularia tricolor* is a widespread species occurring from northern Argentina to Venezuela, showing great morphological variability in overall size and flower color, sometimes overlapping with the closely related *U. amethystina* in some characters (Taylor 1989). In Paraíba it grows both as


Figure 6: A) *Utricularia nigrescens* Sylvén; B) *Genlisea filiformis* A.St.-Hil.

an annual and as a perennial, occurring in wet to dry sandy soils among sparse grasses. The flowers observed were lilac with the base of the lower lip colored in yellow and white, measuring 1.5-2 cm in length, on scapes 5-8 cm high.

*Utricularia triloba* (Fig. 4A) was one of the first carnivorous plants I ever found in Paraiba, in 2010, and it was also the first time this species was collected in this state. It is distributed in Central and South America, including most of Brazil except the southernmost states (Taylor 1989). In Paraíba I observed it growing under full sun in sandy soils dry or humid at several places along the coast. *Utricularia triloba* is very similar to *U. subulata*, but is most easily distinguished by the three projecting nerves on the sepals (Taylor 1989). It grows both as an annual and as a perennial and was observed with yellow flowers measuring around 1-1.5 cm in length on scapes 5-10 cm high.

*Genlisea filiformis* (Fig. 6B) was found growing at a few locations in seasonally wet sandy soils near water courses. This is the most widespread of all *Genlisea* species, occurring over most of Brazil (except the southernmost states), as well as in other countries of northern South America and Central America (including Cuba), even extending into southern Mexico (Taylor 1991). In Paraíba I have found this annual species in areas between 150-180 m elevation, *c*. 20-25 km from the coast, bearing creamy-yellow flowers measuring 0.4-0.7 cm long on scapes 4-9 cm high.

*Genlisea repens* was also not recorded from Paraíba state until I collected it in 2012. This widespread and common perennial species occurs in Venezuela, Guyana, Paraguay, and throughout Brazil (Taylor 1991), but was previously unknown from coastal habitats. I observed it occupying a large area *c*. 20 km from the coast at 150-180 m elevation, where it is locally abundant and forms an extensive population in sunny flooded sandy areas along streams. All the flowers observed at this

site were creamy-yellow with only the base of the lower lip colored in the more typical bright yellow, measuring around 0.5-1 cm long on scapes around 4-6 cm high.

*Drosera communis* (Fig. 4B) is a perennial species widely distributed in Brazil and neighboring Venezuela, Bolivia, and Colombia (Diels 1906; Dawson 1938; Maguire & Wurdack 1957; Correa & Silva 2005). Although common in highlands above *c.* 500 m elevation in Brazil, this species strangely occurs along coastal habitats from Paraíba to northern Bahia (Silva 2007). In Paraíba it was observed in wetlands near springs *c.* 5-20 km from the coast, between 20-180 m elevation, forming small populations under full sun. The reddish leaves measured around 0.5-1.5 cm in length and the white flowers were about 1 cm in diameter, borne on scapes measuring around 5-12 cm high.

*Drosera sessilifolia* (Fig. 3C) is widely distributed in northern South America, including most of the northern half of Brazil as well as Venezuela and Colombia (Correa & Silva 2005). In Paraíba, this annual species occurs in areas 20-30 km from the coast, between 140-200 m elevation, forming both small and large populations under full sun in seasonally wet sandy soils or wetlands. The leaves are yellow-green to orange-green in color, measuring around 1-3 cm in length, and the pink flowers are about 1 cm in diameter, borne on scapes 10-30 cm high.

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# MY TECHNIQUES FOR THE INDOOR CULTIVATION OF *HELIAMPHORA*

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Keywords: *Heliamphora*, cultivation, indoor.

Until recently the indoor cultivation techniques of *Heliamphora* consisted mainly of tribal knowledge amongst hobbyists. Such information had the new grower overly apprehensive of growing some of the most beautiful of carnivorous plants (Fig. 1 & Front Cover).

Over the last few years cultivation techniques have been refined to the point where *Heliamphora* are no longer considered so difficult. With just a minimal investment, not only can they be grown, but also grown well. To be successful long term you must keep their conditions cool, bright, and humid.

The techniques I am about to describe are by no means the only successful method. Many growers use techniques different than mine. The following methods are what I have found work best for me through experimentation, trial and error, as well as extensive research.

## Substrate

Over the years I have tried many media mixes including: pure cypress bark, pure *Sphagnum*, and my current blend of Aquatic Plant Soil (APS), perlite, and long-fibered *Sphagnum* moss (Fig. 2). Some of my best growth has been with cypress-based mixes. I found that these particular mixes also have their disadvantages. One was that the cypress mixes consisted of voids that small, fragile divisions had trouble rooting into. The roots would hit a chunk of cypress and start circling in on itself. Secondly, the cypress-based mixes required extensive watering. At one point I was watering several times a day.

After much experimentation, I have finally settled on a 1:1:1 mix of Aquatic Plant Soil, perlite, and long-fibered *Sphagnum*. This mix has proven to be an excellent performer. The APS is an excel-

Figure 1: A beautiful example of *Heliamphora* cultivated indoors using the techniques outlined in this article.

Figure 2: Left to right: Perlite, long-fibered *Sphagnum*, Aquatic Plant Soil.

lent moisture buffer. In addition, this mixture is also practically void free. Young divisions have little problem rooting into this mix.

One disadvantage that I have noticed is if this mix is used with hard water, mineral deposits will eventually accumulate in the APS. This can result is the formation of unsightly mineral salt build up that may reach toxic levels over time.

## Pots

*Heliamphora* will develop a quite extensive root system (Fig. 3). This is a case where bigger is better. I have most of mine in large, 6×6×6-inch pots. I have noticed over the years that *Heliamphora* dry out much faster when root bound. I know of good growers who have lost prized specimens due to this issue.

## Water

*Heliamphora* do not seem too picky about water quality. I believe that 0.00 ppm water is neither natural nor desirable. I prefer a purity level for *Heliamphora* somewhere in the range of 10-20 ppm. In the past, I even routinely watered my *Heliamphora* with ¼ strength orchid fertilizer with good results.

I feel it is very desirable to water frequently using top watering or some method that allows the water to drain through the substrate. Whichever method you use, when the water drains from the pot, a negative pressure zone is formed behind it. Fresh air is then forced into the root zone by the atmospheric pressure. This results in a more complete gas exchange and the prevention of any anaerobic

Figure 3: Typical root structure of *Heliamphora*.

conditions. My automated watering system fills the top chamber first. Once the water level is about 0.5 cm below the plant surface a drain cycle begins. The drain cycle then empties the top chamber and fills the lower chamber and the process continues.

Watering frequency will be determined by your substrate choice, air circulation, lighting, plant growth, *etc*. What works for one grower may not work for another. *Heliamphora* are found *in situ* growing in areas having very high rainfall amounts, and are often photographed standing in water. It should be considered that the water they are standing in is fresh and highly oxygenated from frequent rainfall. When you repot, if you notice the substrate smells bad, that is an indication you have issues with your watering regime and substrate choice. Personally I use an automated, recycling watering system which operates every other day. My water reservoir also contains airstones. I feel this more closely mimics the oxygen saturation levels of natural rainfall.

## Lighting

Currently, my lighting format of choice is fluorescent T5 fixtures. I have tried bulbs with color temperatures of 4100 K to over 6700 K. I seem to get the best overall performance from 5000 K bulbs. I feel with good quality bulbs the performance differences are minimized.

My current bulbs of choice are a mixture of Giesemann's Aquaflora© and Midday© bulbs. I typically use bulbs for two to three years before replacing them. One of the major advantages of the T5 format is their excellent lumen maintenance level.

I have found the reflector used can make a substantial difference in the performance of the lighting. Two thirds of linear fluorescent bulbs are pointed in the wrong direction. A good reflector

design can recover most of this lost energy. Look for fixtures with individually faceted or directional type mirrored reflectors.

I try to keep my plants within a few inches of the bulbs (Figs. 1, 4, 5). However, I feel that there is a point of diminishing returns. Being too close reduces the effectiveness of the bulbs adjacent to the one directly above the plant.

The typical running temperature of a T5 bulb is over 65°C. You must prevent the plant from making contact with the bulb. I use cross ventilation and evaporative cooling to help maintain proper temperatures. This will be discussed in more detail later.

My summer time photoperiod is 18/6 and wintertime is 12/12. With *Heliamphora*, an argument can be made about the need for any seasonal change. My observations indicate it has no effect on the plant flowering cycle and no dormancy period is required.

## Temperature

As a rule of thumb, the higher the temperatures the more difficult *Heliamphora* cultivation will be. I can tell a difference in my plant's overall health when temperatures exceed 24°C for extended

Figure 4: *Heliamphora* growth chamber.

periods. It has long been thought that one of the conditions related to outbreaks of "*Heliamphora* Sudden Death Syndrome" are temperatures exceeding 26°C.

I have never had any significant diurnal variation, but I do have seasonal. My summer temperatures average in the low 20°C. and my winter temperatures will average in the low 15°C.

## Cooling and Humidity

To help maintain proper temperatures I use two, low velocity fans (Fig. 6). Each is powered by an individual power supply on the same timer as the light. This provides a level of redundancy if one fan or one power supply fails. This is critical in my opinion. Enclosed plant racks illuminated by four- or six-bulb T5 fixtures will reach critical temperatures if your only source of ventilation was to fail. Using such redundancies has saved my collection more than once.

Fans are placed on one end of the plant rack, blowing just above the pitchers and just below the light fixture. You do not want to cool the bulbs, but form a region of cool air between them and the plants. T5's are designed to run hot and any cooling of the bulbs will reduce their output significantly.

Increasing airflow will also result in a significant drop in relative humidity. To counteract this drop, some type of supplementation is needed. *Heliamphora* can be grown in moderate humidity levels, but for optimum growth and nectar spoon development you will want to supplement.

In my system I use an ultrasonic humidifier. Its "fog" outlet is just below and to the center of the two fans. This placement assures its output is thoroughly mixed into the airflow. The evaporation of the mist from the humidifier also provides additional cooling capacity as well as the increase in humidity levels. The humidifier is also on the same timer as the lights and fans. Everything runs when the lights are on and the cooling demand is the greatest. This system works extremely well in my moderate ambient conditions.

Figure 5: Intense, good quality lighting is essential for colorful indoor *Heliamphora*.

Figure 6: Dual low velocity fans on separate power supplies provide fail safe redundancy.

## Fertilization

*Heliamphora* do best with routine fertilization. I used to root feed once a month with ¼ strength orchid fertilizer. This method resulted in good growth, but I didn't like the side effects. One result was an abundance of "carpet moss". This undesirable moss would form a layer so thick it had to be removed on a regular basis. Another negative result from the fertilizer is the suspected detrimental effect a nitrogen-rich environment has on *Trichoderma atroviride*. It is commonly thought that nitrogen-rich environments result in a reduction of the *Trichoderma*'s beneficial phytoantagonistic characteristics.

I now feed the pitchers directly with Hikari© Cichlid Staple, medium-sized fish pellets. This seems to give me the same performance as the root feedings, but without the negative side effects. Occasionally, I will also give the pitchers a diluted fertilizer mix. I typically prefer this route when rooting new divisions or nursing a damaged plant back to health.

## *Trichoderma*

*Trichoderma* spp. are beneficial fungi that form a symbiotic relationship with the plant. This relationship increases nutrient uptake, enhancing growth, and attacking phytopathogens. When I first started growing *Heliamphora* I had what I felt were excessive losses from what appeared to be "*Heliamphora* Sudden Death". HSD has been shown to be a fungus that can remain dormant until the plant is weakened or stressed at which point it becomes active and plant's death soon follows.

Since I started using *Trichoderma*, losses from HSD have so far been non-existent. I initially experimented with various species, strains, and products and found Ampacbiotech.com's products to work best for me. It is a *Trichoderma* blend with their proprietary strain of *T. atroviride* being the primary species.

To gain the most benefit, *Trichoderma* should be used routinely. While *Trichoderma* does attack fungal pathogens, the pathogens' growth rate may exceed that of the *Trichoderma*. This makes maintaining a healthy culture critical for peak performance. I use a monthly drench and soak new divisions overnight prior to planting or shipping (Fig. 7).

There are many peer-reviewed research papers on the effectiveness of *Trichoderma*; I encourage anyone interested in learning more to do further research.

## Taking Care of New Divisions

When receiving new *Heliamphora*, their roots are usually damaged and sometimes nonexistent. This poses the problem of desiccation due to transpiration and evaporation. In other words, the plant's water loss exceeds water intake and desiccation occurs. If severe enough, the damage will exceed the ability of the plant to recover. This process can occur in as little as a day. The plant will look shriveled up and dry; it is easily recognized once the damage occurs.

The first thing I like to do with a newly arrived division is soak it overnight in a *Trichoderma* solution (Fig. 7). This assures me the plant and roots are fully hydrated, inoculated, and ready for repotting. In this state any further damage is reduced as much as possible. After potting, covering the plant ("Bagging") (Fig. 8) and pitcher feeding with a diluted fertilizer mix are recommended practices.

This helps nurse the plant until the tender roots recover and new growth is observed. We want to keep the humidity levels high, airflow low, and temperatures reasonable. Then we slowly acclimate through a gentle introduction into the new environment. This can be done by slowly increasing the plants exposure to its new environment. Common methods include cutting the corners of the bag or poking holes in them over a period of two to three weeks.

## Dividing Your *Heliamphora*

Some species of *Heliamphora* almost divide themselves, whereas others form tight clumps with all their roots coming from a central mass. The day prior to dividing, make sure to water the plant well.

It is necessary to make sure everything is hydrated and flexible as possible to limit damage.

Figure 7: New divisions soaking in a *Trichoderma* solution prior to planting or shipping.

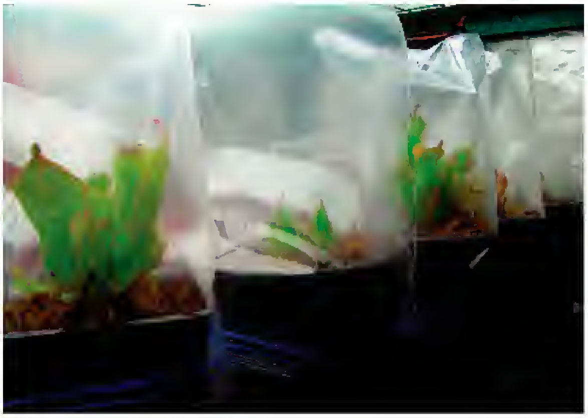

Figure 8: Bagging new divisions until new growth is observed is a commonly used technique.

I start by unpotting the plant and placing it in a container of water. I then gently tease any remaining substrate from the root mass. Look for the plant's natural division points (Fig 9). If it is one of the specimens easy to divide, this will be obvious. Gently work the division free from the main clump, and work its roots free from the main mass. Typically they separate with just a little effort and force. I find it is best to do this with the root mass submerged in water.

If it is one of the specimens difficult to divide, getting divisions with roots will be much less likely. In that case, sometimes the best that can hope for is a division with a good chunk of rhizome at its base. These are easy to root using the methods already described.

Acknowledgments*:* A special thank you to Crystal Morgan and Ron Lane. Without you this article would never have happened.


Figure 9: This specimen made taking divisions an easy process. Notice the natural separation points.

## New cultivars

Keywords: cultivar: *Cephalotus follicularis* 'Clayton's T Rex', *Dionaea* 'Bec de Lièvre', *Dionaea* 'Iris', *Dionaea* 'Cheerleader', *Dionaea* 'St. Patrick's Beard', *Sarracenia* 'Mesa Exotics', *Sarracenia* 'Stingray', *Sarracenia* 'Vintner's Treasure'.

### *Cephalotus follicularis* 'Clayton's T Rex'

Submitted: 12 June 2013

*Cephalotus follicularis* 'Clayton's T Rex' is the cultivar with the largest and rarest of all the teratological traps, up to 5 cm long and 5 cm deep (Fig. 1). These grow horizontal, out from the crown, and their most distinguishing feature is the reverse or 45° backward sloping pitcher. Rather than having a lid, it has what can only be described as horns; these seldom open however. I have named this clone *Cephalotus follicularis* 'Clayton's T Rex'. The Clayton after myself, commemorating my uninterrupted 25 years of involvement in commercial carnivorous plant production. The 'T Rex' because it is the undisputed king of the teratological leaved *Cephalotus follicularis.* Teratological traps are produced along with the normal carnivorous traps. However, when grown commercially, under controlled conditions at Triffid Park, these will grow at any time of the year. At the time of writing, it is not known if the teratological leaves/traps are carnivorous or not. They are long lasting, and will persist for 12 months or more. The clone is stable in cultivation, but only produces teratological traps rarely. Propagation is by any of the standard vegetative techniques used for *Cephalotus follicularis* including tissue culture.

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Figure 1: *Cephalotus follicularis* 'Clayton's T Rex'.

*Dionaea* 'Bec de Lièvre'

Submitted: 27 June 2013

The parentage of *Dionaea* 'Bec de Lièvre' is unknown because this plant was found in a garden center in September 2010. *Dionaea* 'Bec de Lièvre' was named in December 2012 by the author.

Petioles are regular, green and carry deformed traps of about 2.5 cm (Fig. 2). The frequency of these deformations is random, but occurs more frequently in summer and autumn. The traps are tinged with a red color of variable intensity. The plant is vigorous and quickly produces a dense bunch of leaves and traps.

*Dionaea* 'Bec de Lièvre' must be reproduced vegetatively by rhizome or leaf cuttings to preserve the characteristics of the cultivar.

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Figure 2: *Dionaea* 'Bec de Lièvre' plant and deformed trap.

*Dionaea* 'Iris'

Submitted: 27 June 2013

The parentage of *Dionaea* 'Iris' is unknown because this plant was found in a garden center in September 2010. *Dionaea* 'Iris' was named in December 2012 by the author.

Figure 3: *Dionaea* 'Iris' plant and trap.

Petioles are long, light yellow and with the margins bent upwards (Fig. 3). The traps are about 3 cm. The color of the inside of the young traps is light yellow. Over time, fine red stripes appear, only inside the traps. This tint intensifies throughout the season. The mature plant carries traps with tints in all stages of intensity.

*Dionaea* 'Iris' must be reproduced vegetatively by rhizome or leaf cuttings to preserve the characteristics of the cultivar.

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*Sarracenia* 'Mesa Exotics'

Submitted: 12 June 2013

*Sarracenia* 'Mesa Exotics' (Fig. 4) is a complex hybrid of *S.* [(*oreophila* × *flava*) × *purpurea* subsp. *venosa*] × 'Royal Ruby' which I made in the spring of 2000. Seed was grown between myself (PF) and Don Elkins and a division of this clone was given to me in 2006 from the seed batch Mr. Elkins grew. I immediately selected it as special and coined the epithet.

The pitchers grow prolifically throughout the season, but are at their largest and most robust from spring through early summer. Mature, well-grown plants will carry pitchers 50-75 cm tall and 5-7.5 cm wide at the mouth, or possibly greater if grown in high humidity. The lids are slightly wider and longer than the mouth and gently undulate. Pitchers start out green with red veins, but as they mature the colors intensify and become a pale creamy green overlaid with thick, glowing, brilliant rust red veins with hints of magenta. These colors extend from the hood downward the entire length of the pitcher. By fall the entire inside of the throat is a shimmering plum purple which contrasts magnificently with the gorgeous exterior colors.

Flowers are a pale red to reddish orange based on the heat index during bud development and are carried in mass profusion on well-grown clumps. Propagation must be *via* division and cuttings in order to maintain this plant's unique features.

This cultivar's epithet pays homage to my friend Don Elkins and his cp nursery Mesa Exotics.

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Figure 4: *Sarracenia* 'Mesa Exotics'.

## *Sarracenia* 'Stingray'

Submitted: 12 June 2013

*Sarracenia* 'Stingray' (Fig. 5) is a highly complex hybrid of *S.* [(*rubra* × *oreophila*) × (*purpurea* subsp. *venosa* × *leucophylla*)] × 'Judith Hindle' which I made in the spring of 2003. The resulting seed was grown and this extraordinary individual was selected in 2008 and finally named in 2013. It had previously existed in my and others' collections.

Adult pitchers are 40-50 cm tall and 4-6 cm wide at the mouth. The large, ruffled, white hood is held high on a 4-6 cm tall extended neck and is slightly overlapping with deep red veining outlining the brilliant white areolae and is beautifully suffused with varying shades of green and gold. New pitchers are flushed light pink when they first open then age to bright green heavily overlaid in the upper, outer throat region with white areolae outlined in red. The nectar roll is deep red as the pitchers age and this red color extends down the ala giving the plant a vertical red striped effect. As the pitchers age the areolae in the hood become a brilliant, sparkling white with red veining and buttery gold highlights filling in the spaces between them.

Flowers are peach overlaid with light pink and are beautifully striped red on the outer sepals. Propagation must be *via* division and cuttings in order to maintain the plant's unique features.

This cultivar's large, undulating hood reminds me of the graceful waving motion of the wings of a swimming stingray which was the inspiration for its name.

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Figure 5: *Sarracenia* 'Stingray'.

## *Sarracenia* 'Vintner's Treasure'

Submitted: 12 June 2013

*Sarracenia* 'Vintner's Treasure' (Fig. 6) is a primary *S. moorei* hybrid of *S. leucophylla* × *flava* var. *ornata* which I made in the spring of 2005 and selected in 2008.

This is a very vigorous and hefty pitcher plant reaching heights of 80 cm or more on well-established older plants. High ambient humidity during the growing season ensures big, robust pitcher growth. Pitchers start out green overlaid with a medium red with a scattering of white areolae directly under the nectar roll extending downward 4-7.5 cm. The hood is heavily marbled with pink/red veins and large white areolae which later become pink and red flushed. The hood is large and heavily ruffled approximately 10-15 cm wide from side to side and 10-15 cm long from the

Figure 6: *Sarracenia* 'Vintner's Treasure'.

back to the front. The fluted mouth attains comparable sizing with the hood and has a very smooth and glossy appearance.

As the pitchers mature they take on a darker green color suffused with varying shades of deep red, especially in the uppermost regions below the mouth, with an intensely shimmering, deep plum purple throat which extends down the interior length of the neck for some distance. The effect is stunning in bright light. In late summer, a secondary set of pitchers are produced that are nearly equal in size and development to the early season's first pitchers.

Flowers are red and typical for a *S. moorei*. Propagation must be *via* division and cuttings in order to maintain this plant's unique features. This cultivar's epithet pays homage to my favorite vini (wine) colored *Paphiopedilum* orchid with which it shares similar colors.

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*Dionaea* 'Cheerleader'

Submitted: 29 June 2012

The parent plant was discovered in early spring 2009, while visiting Lois Ochs extensive carnivorous plant collection at her nursery in Penngrove, California. Lois indicated this unusual Venus Flytrap with fuzzy traps was originally given to her by another Bay Area Carnivorous Plant Society member Mike Wang.

A few weeks later, Lois gave me a flower stalk from the plant, which I placed into tissue culture. The culture was successful, and during summer 2010, subsequent subculturing resulted in a few jars of cloned plantlets (Fig. 7). I had Lois deflask, transplant, and save a few of the clones, which she returned to me later that summer.

During the late summer/fall, one of the specimens began to grow much larger and faster than the others. As it grew, I noticed the successively emerging traps were losing the fuzzy appearance, and eventually newly emerging traps began to look "normal", with smooth outer lobes and long protruding teeth on the outer margins. Eventually, the entire plant was producing "normal" looking leaf traps.

Figure 7: A flask of tissue cultured plants showing the fuzzy traps (left); mature *Dionaea* 'Cheerleader' plant with normal traps and new fuzzy traps on rhizome offshoots (right).

In late April 2012, this larger specimen with normal looking traps had developed additional offshoots with the distinctive "fuzzy" traps (Fig. 7). This is the typical growth behavior of *Dionaea* 'Cheerleader' – that is, fuzzy traps appear each spring as the plant emerges from dormancy and new offshoots develop. These fuzzy traps do not grow into normal traps, but eventually die, while, as the season progresses, additional newly emerging traps grow into normal traps. This leads me to believe that the genes responsible for the "fuzzy" traps are present and for some reason get "switched off" when the plant reaches a certain size, age, or stage of development, but can be re-activated in new young offshoots, divisions, leaf pullings, or in young plantlets propagated through tissue culture. The annual recurrent pattern of fuzzy traps in mature plants of this cultivar has been replicated by several growers.

The flower appears to be normally formed (Fig. 9).

Plants with fuzzy traps have commonly been discussed since at least 2001 using local names such as "PomPom", "Hedgehog", or "Scrub Brush", but the fuzzy traps on these plants have been reported to eventually give way to plants with normal traps. Further, I am not aware of any publications reporting that fuzzy traps reappear in subsequent years as the plants emerge from dormancy or produce offshoots. These common names have never been formally registered with the International Cultivar Registration Authority (ICRA).

The name *Dionaea* 'Cheerleader' was coined on 10 April 2013 because the roundish fuzzy traps are reminiscent of the pom poms used by cheerleaders. *Dionaea* 'Cheerleader' must be propagated by vegetative means to maintain its characteristics.

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## *Dionaea* 'St. Patrick's Beard'

Submitted: 29 June 2012

*Dionaea* 'St. Patrick's Beard' is a tissue culture sport from a *Dionaea* 'Cheerleader' (described above). During spring 2011, a large *Dionaea* 'Cheerleader' with traps that ranged from fuzzy to normal looking traps (Fig. 7) produced a flower stalk with normal looking flowers (Fig. 9) which was placed into tissue culture. The resulting jars of subcultured plantlets were largely neglected until early 2012, when many of the plantlets had died. The remaining live plantlets were finally deflasked

Figure 8: *Dionaea* 'St. Patrick's Beard' has downward pointing beard-like protrusions on the base of intermediate traps transitioning from entirely "fuzzy" backed traps toward traps somewhat resembling a strange combination of *Dionaea* 'Cupped Trap' and *Dionaea* 'Wacky Traps'.

Figure 9: *Dionaea* flowers: typical (left) and 'Cheerleader' (right).

Figure 10: *Dionaea* flowers: 'Wacky Traps' (left) and 'St. Patrick's Beard' (right).

and transplanted. Many of the intermediate transitioning traps had remnants of the fuzz, in the form of raised striations on the outer lobes, oriented vertically from the trap midrib to the outer margin, and a massed clump of spike-like protrusions near the base of the trap, giving the appearance of a "beard". The traps on one of these plants had an appearance somewhat resembling a strange combination of *Dionaea* 'Cupped Trap' and *Dionaea* 'Wacky Traps'. This is the cultivar *Dionaea* 'St. Patrick's Beard' (Fig. 8). The flower petals are narrower than those of "normal" *Dionaea* (Fig. 9), but wider than those of 'Wacky Traps' (Fig. 10). Also, the stigma seems to be deformed similar to that reported for 'Wacky Traps'. The plant has been grown in several collections and the characteristics are stable.

*Dionaea* 'St. Patrick's Beard' is named for the downward pointing beard-like protrusions present on the base of intermediate traps transitioning from entirely "fuzzy" backed traps toward "normal" looking traps, the predominantly all-green color of the plant, and St. Patrick's day 17 March 2011, the date I introduced this cultivar into tissue culture propagation.

Vegetative propagation is necessary to maintain the unique characteristics of this plant.

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# ICPS

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